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Instrumentation

REMOTE CONTROL OF THE LITR

J. A. Cox
L. C. Oakes
W. H. Tabor

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE NUCLEAR COMPANY
A Division of Union Carbide and Carbon Corporation
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By: J. A. Cox
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Date Issued AUG 15 1956

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REMOTE CONTROL OF THE LITR

J. A. Cox L. C. Oakes W. H. Tabor

Introduction

The LITR remote control system, with the remote panel located at the Graphite Reactor control desk in Building 3001, was placed in operation on October 12, 1955.

A control-system test was made in order to demonstrate that the LITR could be safely controlled from the Graphite Reactor, thus allowing one operator to control both reactors. The operator freed from the control desk at the LITR will then be available for inspection and patrol work, as well as other operational work. The additional inspection and patrolling will, it is believed, increase the over-all safety of operation.

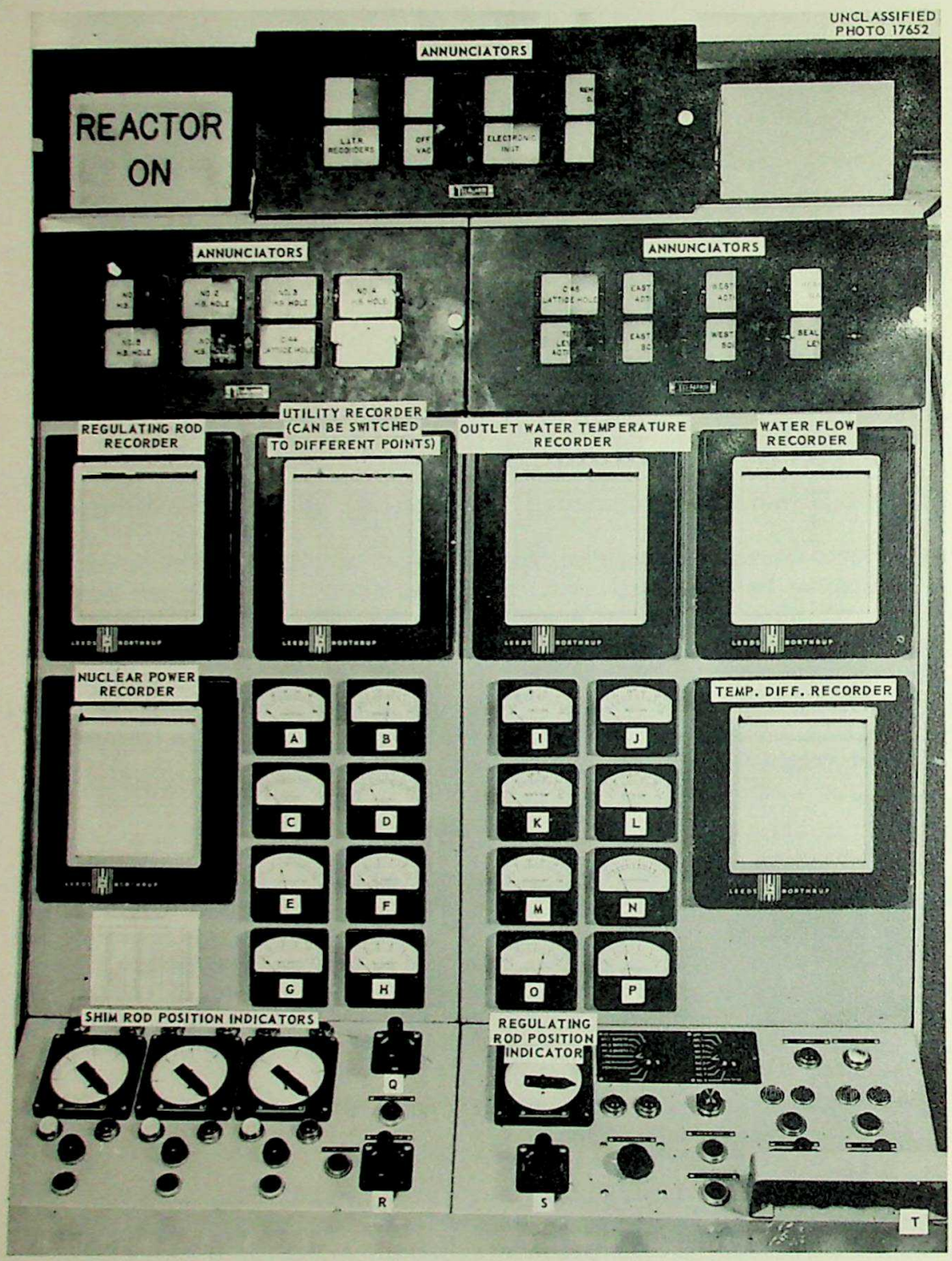
During the test, which is still in progress, all operation (except when the Graphite Reactor was shut down) has been done from the Graphite Reactor control room, with the operator at the LITR control room merely acting as an observer but always available to take over operation if it should become necessary. He was instructed to report any occurrences which required his participation. This operator has continued to record data and to make certain checks which will be performed by a roving operator once completely remote operation begins.

Instrumentation

The remote instrumentation is composed of two groups: (1) the remote recorders and/or meters which receive their signals directly from similar instruments at Building 3005 (LITR), and which have an expected accuracy of 2% (an exception is the multipoint utility recorder, rated at 4%); (2) the remote recorders and/or meters which receive their signals from process instruments such as manometers, and which have a rated accuracy of 5%.

Control panels at the LITR control room and at the remote control room are shown in Figures 1 through 4.

A block diagram of the LITR nuclear instrumentation, together with the remote components, is shown in Appendix A. Appendix B shows the remote instrumentation on the process system. Appendix C describes the LITR annunciators and safety system. Appendix D lists references to the remote system and test results.



A – MONITRONS B – REMOTE DC VOLTAGE C – PERIOD D – % POWER E – COUNT RATE METER
F – NO. 3 SAFETY G – NO. 1 SAFETY H – NO. 2 SAFETY I – EAST FAN J – WEST FAN
K – NORTH PUMP L – SOUTH PUMP M – SPARE N – TANK PRESSURE O – EXHAUST VACUUM
P – SEAL TANK LEVEL Q – SCRAM SWITCH R – SHIM ROD ACTUATOR S – SERVO DEMAND T – COOLING FAN SWITCHES

Fig. 1. Remote Console Located in Graphite Reactor Control Room.

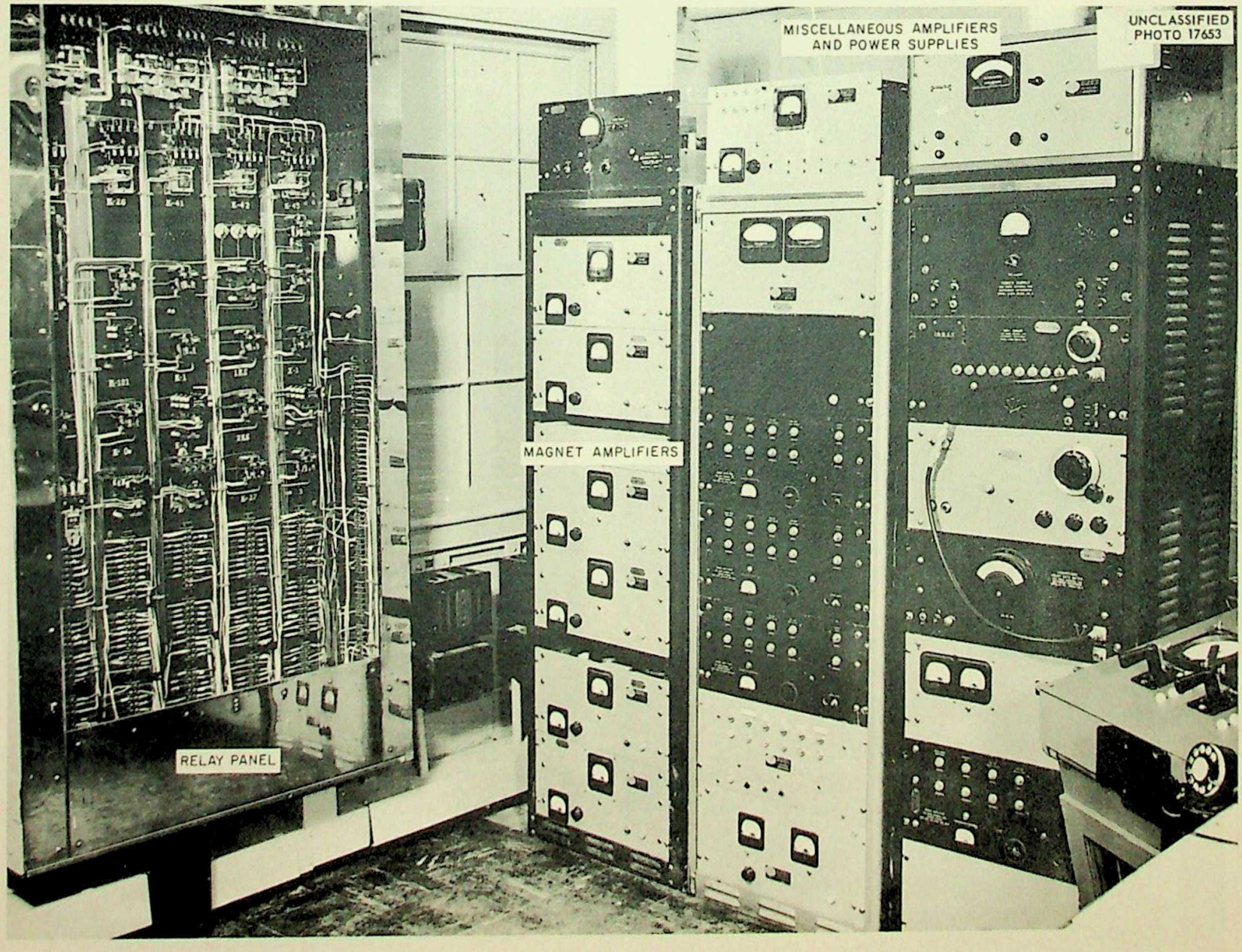


Fig. 2. Relay Panel and Amplifier Racks in LITR Control Room.

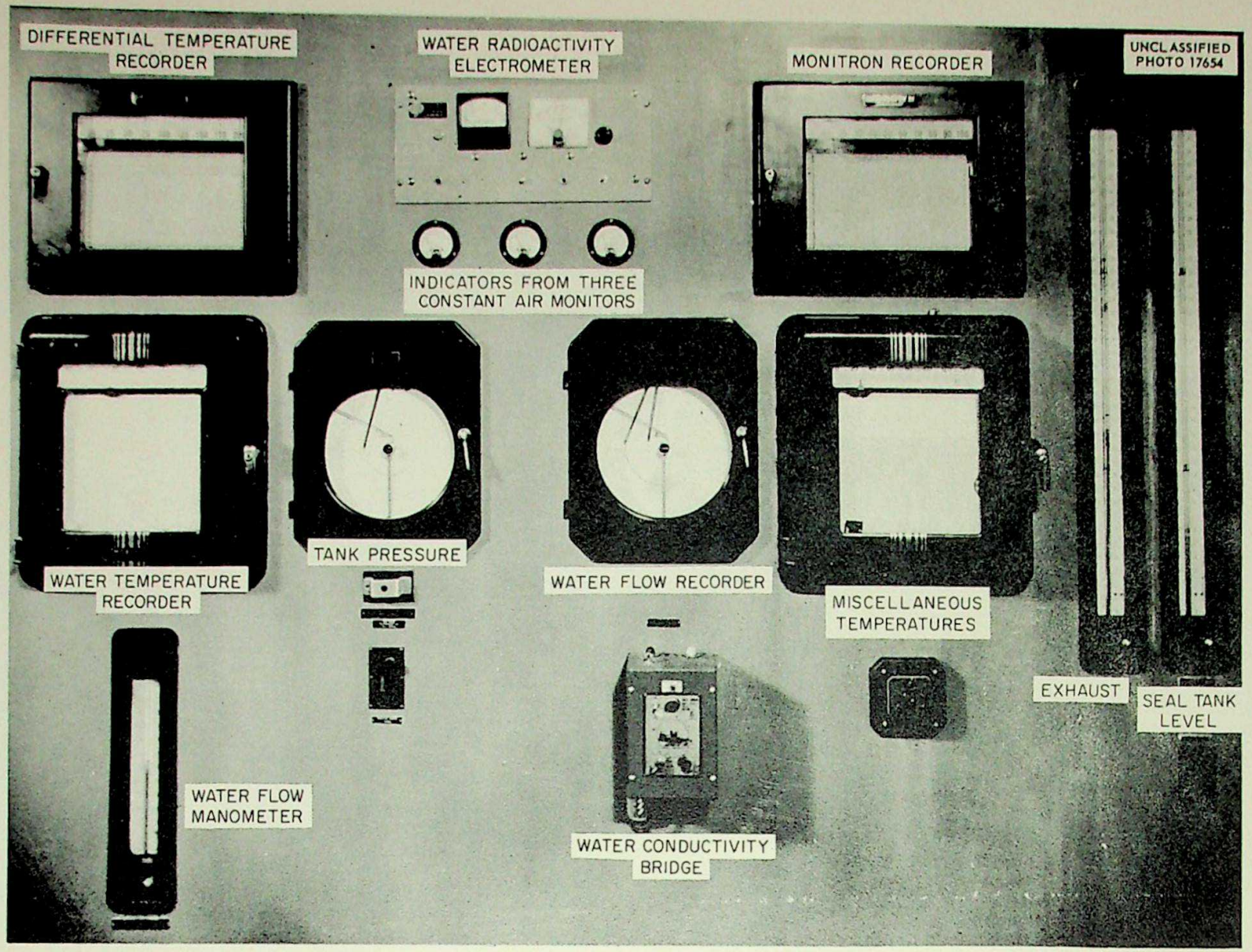
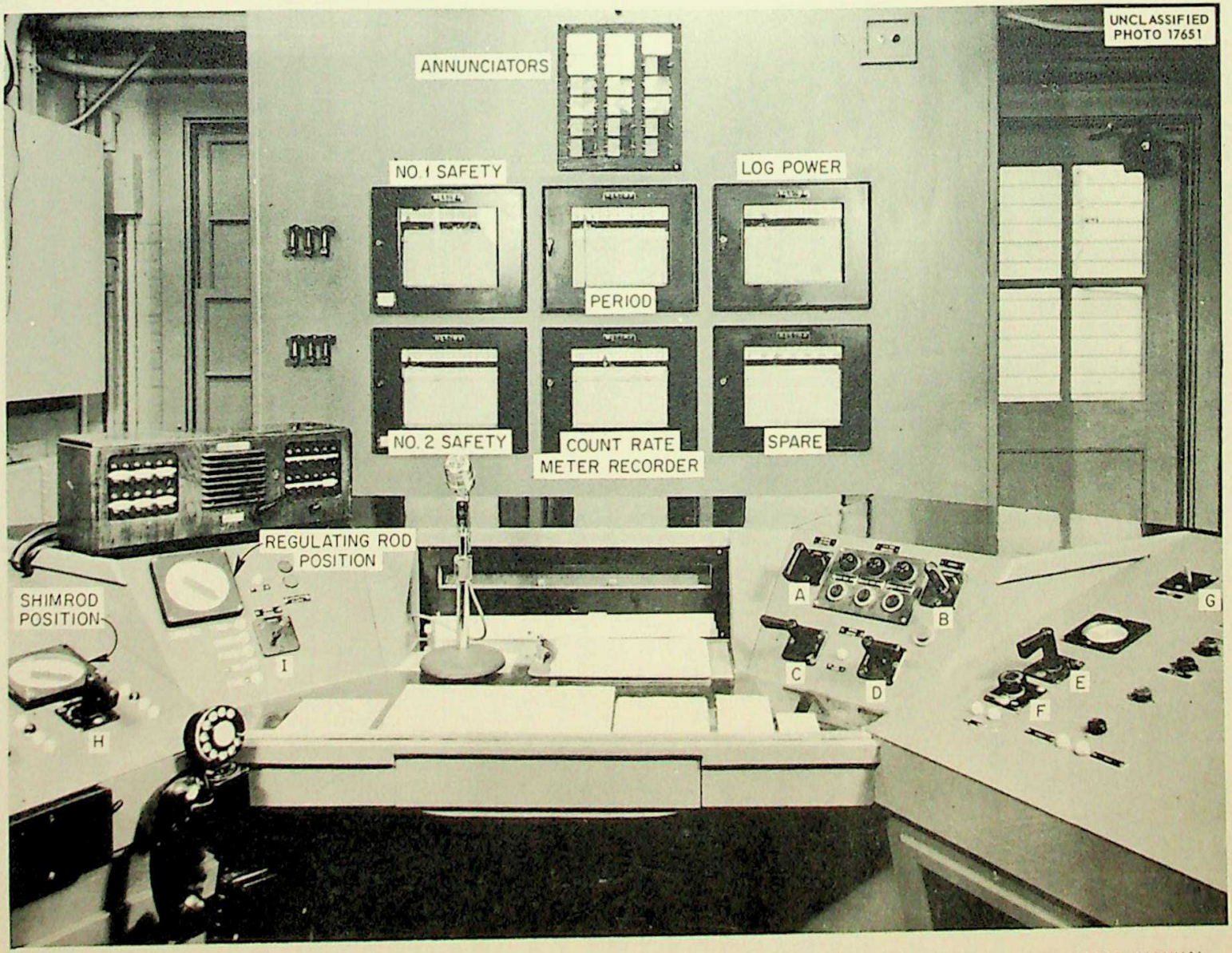


Fig. 3. Process Instruments in LITR Control Room.



A – REVERSE - BYPASS
B – SCRAM
C – INDIVIDUAL ROD ACTUATOR
D – GROUP WITHDRAWAL
E – SERVO DEMAND
F – SERVO VERNIER
G – RAISE CLUTCH
H – SHIM ROD CONTROL
I – SERVO - MANUAL

Fig. 4. Console in LITR Control Room.

Proposed Operational Procedure

When the operator is withdrawn from the LITR control desk and the operation is completely remote, it is planned to provide patrol inspection of the LITR control room every hour for recording data and checking instruments. After experience has been gained, it may be feasible to reduce the frequency of such inspections to about every 2 hours.

Startup of the LITR will be done from the LITR desk rather than from the remote desk until experience and circumstances justify a remote startup. Many troubles with experiments occur during startups, and it is inconvenient for the supervisor in charge of the startups to have to communicate from the remote desk at those times when it is necessary for frequent inspections of experimental equipment to be made. The procedures presently used are described, in some detail, in Appendix E.

After the reactor is started up, control will be transferred from the LITR desk to the remote desk, and the LITR control room will be locked to prevent entry by unauthorized persons. During routine operation from the remote desk the operator will inform the foreman whenever an alarm, shutdown, automatic power reduction, or any other unusual condition occurs; the foreman will go to the LITR to investigate and correct the trouble. This procedure is not unique to the test, since it has been in use for many years.

Another area which will be kept locked is the top room of the LITR, where the top plug of the reactor is located. This room provides access to the control cables and the shim-rod and regulating-rod drive mechanisms. A telephone will be located outside the room and will bear a sign informing personnel desiring entry to call the control desk operator, who will open the door, by means of an electric switch, to authorized persons only. No change in operation of the two experimental rooms on the east and west sides of the LITR is planned. Personnel in these rooms will have access to the remote desk by telephone or intercom. Both experimental rooms and the remote control room is afforded by telephone and intercom. In addition, the remote control room will have a microphone connected to loud speakers by which announcements can be made throughout the LITR area.

Regular inspections (initially, every hour) will be made by an operator to record data and to check instruments which are not remotely monitored. Operators will be available for making many more checks than were possible when two control desks had to be continuously manned.

Safety

The safety trips and interlocks in the LITR instrumentation and control circuitry are not affected by the remote console. The remote recorders, with the exception of the regulating-rod recorder (driven by selsyn transmitter) and flow recorder (driven by pressure transmitter) are driven by slave

slide wires on the LITR recorders. These remote recorders are not equipped with safety trips or interlocks and do not enter into the safety circuit in any manner. The remote meters likewise do not have any trips or interlocks and serve only as monitors of the instruments located at the LITR site.

It is important to note that should the remote facility lose power by a break in the main cables the safety circuit of the LITR will still be intact and uninterrupted. The effect of a broken d-c cable would be to cause all remote recorders and meters to go immediately to zero; a broken a-c cable would put all controls and all lights out of service, including the Tel-Alarm with no audible alarm. Such an event would quickly be recognized by the remote operator.

The LITR alarm annunciators, which monitor unsafe or abnormal conditions in the reactor or experiments, have been duplicated at the remote site. Any abnormal condition actuating the LITR annunciator will simultaneously indicate the trouble on the remote annunciator. These two units work independently of each other; both receive their signal from the source of trouble. Through these annunciators, the operator is warned of trouble by an audible alarm and by a light indicating the origin.

Indication of the background level of radiation and air contamination will be provided by all monitrons and constant air monitors being connected to the LITR annunciator to alarm when radiation conditions are abnormally high. In the event of a release of radioactivity of sufficient magnitude to necessitate an area evacuation, the LITR evacuation horn will be energized by a push button located on the remote console. This will serve as a warning to personnel in the LITR area of the unsafe condition.

Consideration has been given to the fact that an unauthorized person might gain entry to the unattended control room, in spite of the locked doors, and manipulate one of the switches. This, of course, might affect the normal operation of the reactor. In the event that one of the instruments is turned off for any reason, the safety devices on that instrument are, of course, eliminated, and the operator would be warned immediately through the alarm annunciator. He then would take immediate action and have the incident investigated. The primary safeties (on power and period) at the LITR operate through amplifiers independent of recorders.

The result of a control switch being thrown would, of course, depend upon the switch involved. The most dangerous act would be to raise the servo demand and withdraw a shim rod, thus increasing the power. The power would be controlled by safety devices designed to limit it to safe values. The safety devices would automatically reverse the shim rods or, if the power should increase to 50% above normal, scram the rods and completely shut down the reactor. However, such an act is most unlikely since only authorized personnel will be permitted to enter and the site will be locked whenever it is unattended. The other extreme would be for the scram switch

to be thrown, which would shut down the reactor. This, of course, would involve no danger but could at times cause considerable inconvenience. It is believed that the safeguards previously mentioned are sufficient to cover any such acts. A list of switches available in the LITR control room showing effects of misoperation is shown in Appendix F.

Several instruments are not remotely monitored by recorders, meters, or alarm annunciators. It was determined that only patrol inspection of these instruments would be necessary, since their failure would not cause any damage to the reactor. A list of instruments not remotely monitored and the effects of instrument failure are shown in Appendix G.

History of Operation

The success of this installation has been proved by the ability of the remote operator to completely control the reactor during operation. From initial operation of the remote controls to the present time, the remote control operator has had to request help from the LITR operator only on specific jobs which would be performed under remote operator by a roving operator. These include beginning and end-of-shift checks on items such as gas supply, magnet currents, reactor water resistance and pH, and miscellaneous temperature measurements, all of which will be performed by a roving operator once the operator at the LITR is removed.

During the test of remote operation, only two incidents of significance occurred. In one case the d-c voltage supply to the remote instruments fluctuated, causing unreliable readings on the remote instruments. This situation has been remedied by monitoring the voltage supply through the alarm annunciator. The other incident consisted of the remote operator assuming control of the reactor, immediately after the reactor had been started up, with one of the remote recorders turned off. There was no visual or audible sign to indicate the status of the instruments. As a result of this experience it is planned to

1. monitor, through the alarm annunciator, the 110 a-c supply to the important LITR recorders and to the remote recorders thereby actuating an alarm when the a-c supply is interrupted by a power failure or a blown fuse or is turned off with the "off-on" switch;

2. incorporate in the differential temperature recorder a thermocouple burnout protection to cause the instrument to drive full scale when the input signal to the instrument amplifier is lost.

A study of the accuracy of the remote instrumentation was recently completed. From data collected during normal operation, comparative readings of LITR instruments vs LITR remote instruments were used to determine the maximum deviation of the remote instruments. The following results indicate the maximum deviation of remote readings from the readings taken at the LITR:

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1. power indicating instruments: +3.8% -0%;
2. power measuring instruments: +3.4% -2.4%;
3. the remaining instruments exclusive of the log N, fans, and pumps: +10% -0;
4. the maximum deviation of the log N, the fan motor currents, and the pump currents: -25.5% +0, +23% -12%, and -13% +0, respectively.

Included in the errors in No. 4 is the inability of personnel to read the instruments closely (this is particularly true in the case of the log N recorder which has a log scale so that small errors in reading show up as large numerical differences). It is felt that the important nuclear instruments have proved to be reliable.

Summary

The remote instrumentation has proved to be quite adequate to safely control the LITR, and safety will actually be increased by permitting more patrol-type inspection by operators freed from the LITR control desk. As a result of the experience gained in the test, minor additions listed below will be made to the system.

1. The remote recorders, together with the important LITR recorders, will be monitored to ensure that they are operating.

2. An evacuation alarm switch will be installed at the remote desk.

3. A large sign will be posted in the LITR control room to inform personnel of the remote operation; in addition, all doors will be locked.

4. A device for determining whether the door to the upper room is open or closed will be installed. Admittance to this room will be restricted to authorized personnel and will be controlled by the control desk operator.

Acknowledgements

Assistance in design of the system was received from

S. J. Ditto
E. P. Epler
S. H. Hanauer
W. F. Mruk
J. B. Ruble

Suggestions for improvements in design and operation were made by

C. D. Cagle
W. R. Casto
T. C. Weeks

The following shift foremen in charge of operation of the LITR also offered much valuable assistance in operation:

C. B. Gaither
R. D. Hulen
E. D. Lance
T. B. Nixon
C. McBee

APPENDICES

A. Block diagram of control system showing remote instruments.

B. Remote instrumentation for process system.

C. LITR annunciator and safety system.

D. References to remote system and test results.

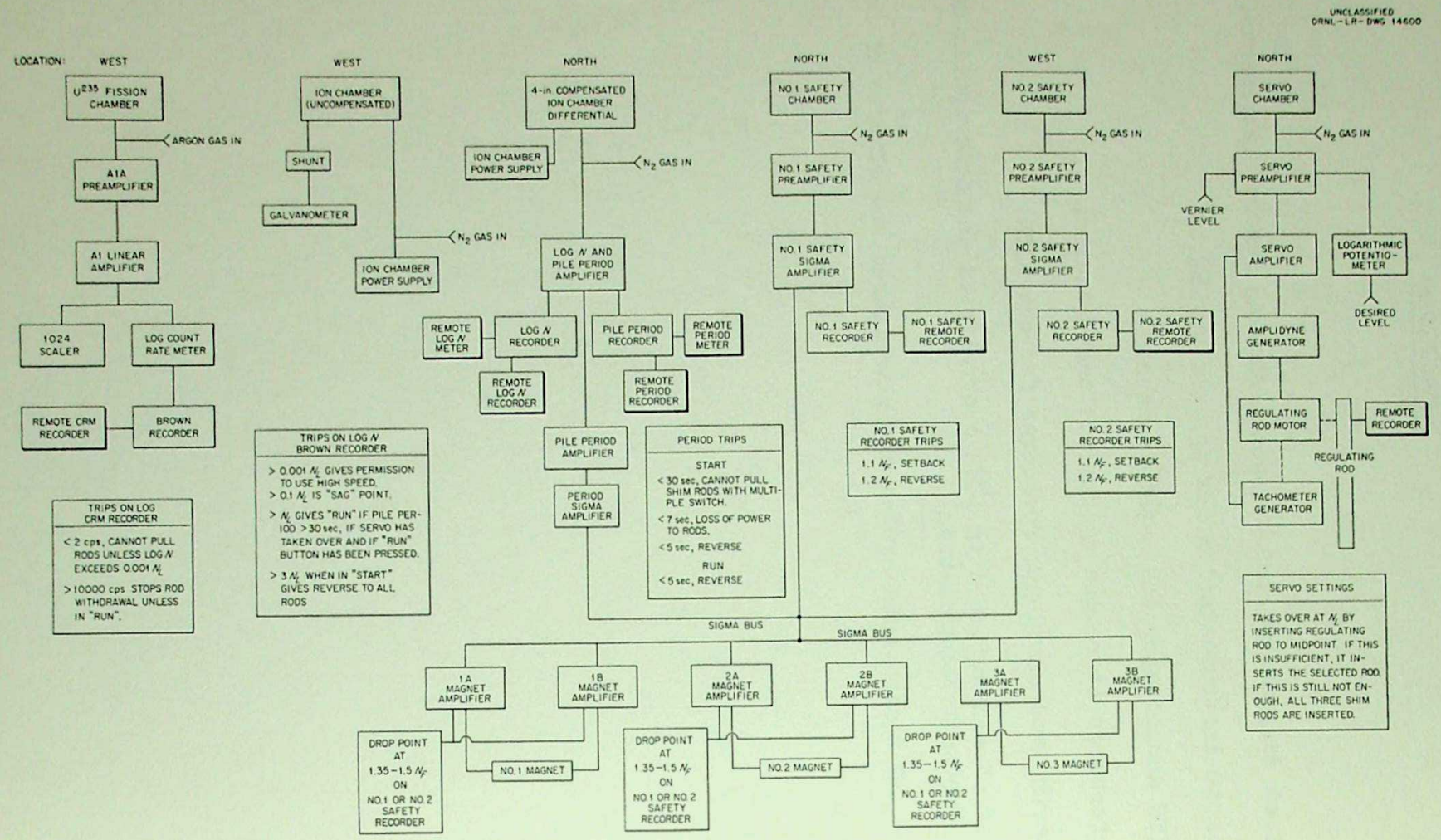
E. Startup and shutdown procedures for the LITR.

F. List of all switches in LITR control room and description of effects of improper manipulation.

G. List of instruments not remotely monitored and effects of failure.

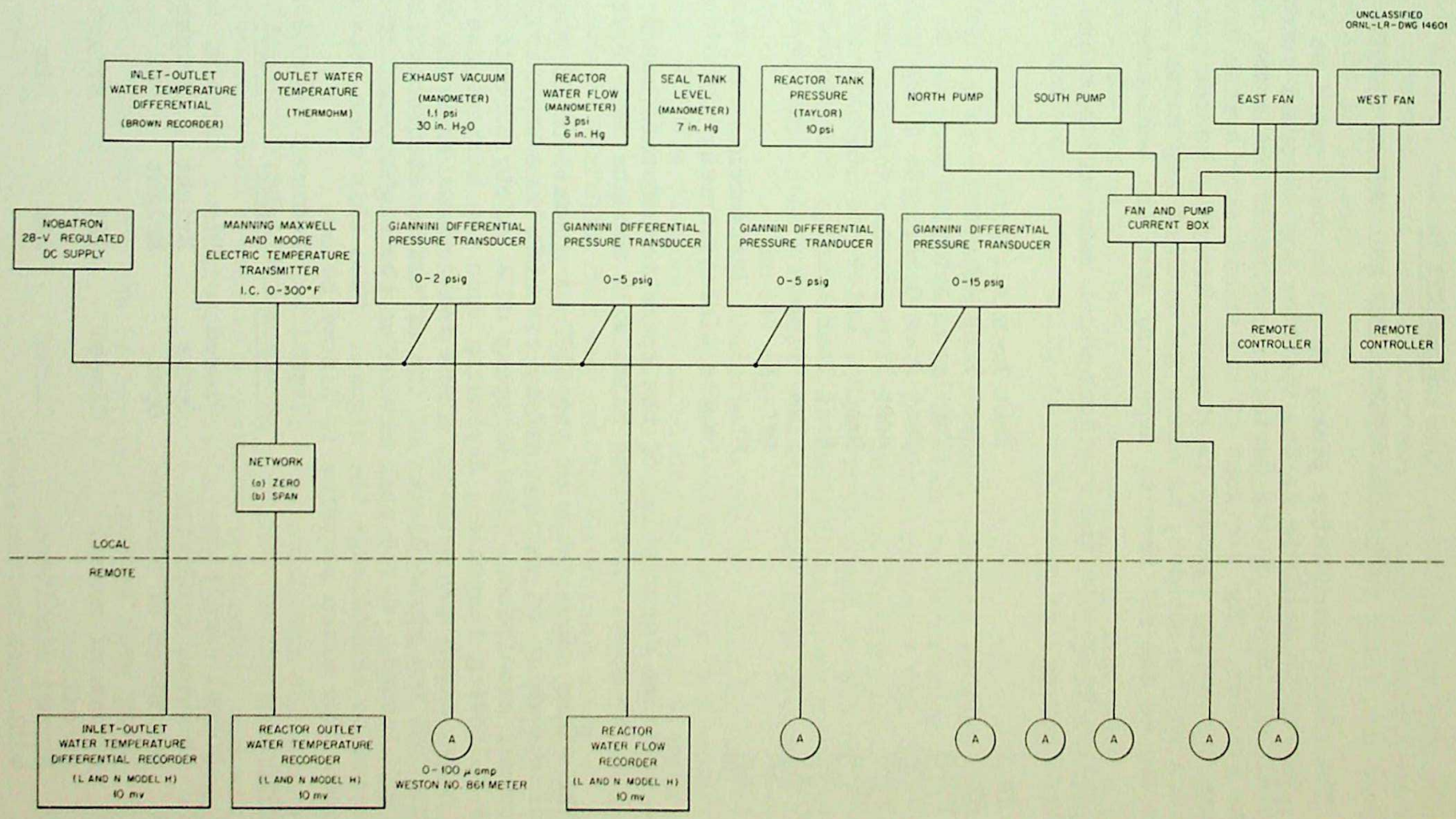
APPENDIX A

BLOCK DIAGRAM OF LITR NUCLEAR INSTRUMENTATION SHOWING REMOTE INSTRUMENTS



APPENDIX B

A BLOCK DIAGRAM SHOWING REMOTE INSTRUMENTATION FOR LITR PROCESS SYSTEM



APPENDIX C

THE LITR ANNUNCIATOR AND SAFETY SYSTEM

The alarm annunciator panel, which is duplicated at the remote control desk, serves to indicate to the operator any abnormal condition which may arise either in any of the various experiments or in the routine operation of the reactor. The stations of the annunciator system are connected to the reactor safety circuit to respond according to the signal received. An alarm may be sounded, an alarm and setback may occur, or an alarm and scram may be the net result, depending upon the seriousness of the trouble.

Listed below are the stations which make up the alarm annunciator panel:

HB-1	East Room Activity
HB-2	West Room Activity
HB-3	Top-level Activity
HB-4	East Room Scram
HB-5	West Room Scram
HB-6	Reactor Water
C-42	Seal Tank Level
C-44	LITR Recorders
C-46	Off-gas Vacuum
C-48	Electronic Instruments
	Remote Direct Current

A detailed description of the operation of this annunciator follows, along with abnormal conditions which will actuate each station.

The alarm annunciator at the LITR is a panel of 21 stations intended to indicate which of various safety circuits have been tripped as a result of abnormal conditions. The tripping of a safety circuit will cause one of the following responses, depending upon the seriousness of the condition: alarm only, alarm and setback, alarm and scram. When any of these occur, both the red and white lights of the offending station will come on and the alarm will sound. A red push button on the right panel of the console must be pressed to acknowledge the signal. When this done, the alarm will be silenced. The alarm sequence is listed below:

Step*	Signal Contact	Red Light	White Light	Audible Alarm
1. Normal condition	Closed	Dim	Dim	Off
2. Abnormal condition	Opens	Bright	Bright	On
3. Operation of acknowledge push button	Open	Bright	Off	Off
4. Return of normal condition	Closed	Off	Bright	Off
5. Normal condition, with push button reset	Closed	Dim	Dim	Off

* If, after step 2, normal condition returns before the acknowledge button is operated, the annunciator must remain in condition 2 until the acknowledge button is operated, after which the annunciator should go to step 4.

  If, after step 4, abnormal condition returns before the reset button is operated the annunciator should return to step 2.

The white light can be turned off by pressing the black push button located below the red acknoledge button.

A small red light above the panel burns during the time that a setback signal is being received. No special light indicates a scram signal other than the annunciator light since a scram is immediately obvious.

Some experiments have time delays in their circuits so that there will be a lapse of as much as 30 seconds between the occurrence of an abnormal condition and a setback or scram. The purpose of the time delay is to prevent setback or scram if the abnormal condition clears itself. If an alarm sounds and the setback light comes on but no setback is experienced, the operator should reduce the power to N_L with the servo or reverse until the abnormal condition has been cleared.

An experiment is tied into the reactor safety circuits by the insertion of continuity plug into the proper socket behind the west instrument panel. If this plug is not in place, no abnormal signals can be received from the experiment; however, the red abnormal light will burn. The red light cannot be cleared in this case but is covered so that it will not be confused with the red lights which indicate abnormal conditions. If a continuity plug is left in place after an experiment has been disconnected, the power level cannot be raised above N_L, and the setback light will burn constantly.

In the event of any alarm, the operator is to press the acknowledge button only, see that a setback occurs if the setback light is burning, and call his supervisor immediately unless he has specific instructions to do otherwise.

The scram relay is common to all scrams connected with the alarm annunciator. This relay is the first one on the left in the panel behind the main control board. Since this is a normally open relay, one will find it energized if scram conditions are proclaimed through the alarm annunciator system.

As of this date the reactor can be scrammed by the following:

1. overvoltage or undervoltage on the magnet amplifiers,
2. the red scram switch,
3. the raise clutch switch,
4. failure of water flow,
5. reactor water pressure exceeding 25 psi at top,
6. electronic scram through No. 1 and No. 2 safeties at 1.5 N_F,
7. electronic scram through reactor period when the period becomes less than 1 second,
8. east room scram switch,
9. west room scram switch,
10. push buttons at experiments.

C42, C44, C46, and C48 Lattice Holes; Nos. 1, 2, 3, 4, 5, and 6 HB Holes.

These stations are all connected to safety circuits that act as monitors for troubles at these experimental facilities. The meanings of the signals from these stations will change with the work going on at these places. Up-to-date instructions on each experiment are always posted on the clip board for each hole and are dated or initialed on or after the last shutdown day.

East Room Activity, West Room Activity, and Top-Level Activity

Through these stations will come the announcement of either a high air activity, as measured by constant air monitors, or a high general activity, as indicated by monitrons. Each monitron and constant air monitor will have a special relay which will originate the trouble signals for the annunciator. The response to trouble is an alarm signal only. When the alarm brings trouble to attention, the multiswitch recorder and the constant air monitron meters will be inspected for location of the difficulty. These meters and the recorder are located on the auxiliary instrument panel.

Off-Gas Vacuum

Only an alarm is given by this station when the off-gas system vacuum drops to lower than 9 inches of No. 3 oil (27 inches of water). This vacuum is measured by a 26-inch manometer on the auxiliary instrument panel through a line from a point just downstream from the off-gas filter box. On this line behind the instrument panel is a vacuum-operated switch which actuates the alarm circuit.

Reactor Water

This station gives only an alarm when any of the following incidents occur:

1. the reactor water exit temperature, as indicated by the Thermohm recorder, exceeds 125°F - a switch on the recorder starts the signal;

2. the water temperature difference across the reactor exceeds 20°F - this signal is initiated by a mercury switch on the differential temperature recorder;

3. the reactor water activity, as indicated by the a-c electrometer, exceeds 80% of full scale - a switch on the auxiliary meter can be set to give a signal at any percentage reading.

This station gives an alarm, stops the pump, and scrams the reactor when either of the following incidents occur:

1. the reactor water flow drops to 0.2 inch of mercury - a switch on the pen mechanism of the flow recorder actuates the safety circuit;

2. the water pressure at the top of the reactor reaches 12 psi - a pressure switch on the instrument line at the recorder gives the signal for the safety circuit.

There is a switch over each of the stems of the reactor exit valve and the reactor by-pass valve for prohibiting the operation of the reactor water pump when both valves are closed. If either valve is open, the pump can be started in the normal manner.

Seal-Tank Level

This station gives only an alarm when any of the following incidents occur:

1. the seal tank level exceeds 7 inches of mercury - the signal is originated by a pressure switch on the dip tube of the bubbler-type depth gauge;

2. the seal tank level decreases to a point lower than 1 inch of mercury - the signal is started by a pressure switch on the dip tube of the bubbler-type depth gauge.

Electronic Instruments

This station will sound the alarm only when any of the following conditions exist:

1. the log N calibration switch is on any position other than "operate"- the switch causing the alarm is in the log N amplifier, but there is

no signal light on the amplifier to indicate exactly what caused the alarm as there is on the sigma amplifiers;

2. the scram is caused by reactor period, No. 1 safety, or No. 2 safety amplifier - each of three amplifiers has a relay which originates the signal, and the amplifier causing the scram will show an abnormal scram light;

3. there is electronic failure in the sigma amplifiers, indicated by four trouble lights on the amplifiers - each amplifier has a relay that originates the signal;

4. there is disconnection of a sigma amplifier (No. 1 safety, No. 2 safety, or reactor period) from the sigma buss - there are no lights on the amplifiers to indicate the cause of an alarm from this source; the disconnection breaks the circuit which was completed through the shield of the connector cable, and there is a single relay for each sigma amplifier on a special panel which sums up the troubles described in 2, 3, and 4 and actuates the annunciator.

East and West Room Scram

Located in each experimental room are manual scram switches for emergency use. When either one is used, an alarm and light will be indicated through the annunciator system in the control room.

LITR Recorders

When any recorder at the LITR control room has been turned off, the alarm annunciator will sound an alarm and this station will show an abnormal light. The alarm can be silenced with the acknowledge button, but the abnormal light will continue to burn until the recorder is turned back on.

Remote Direct Current

The d-c voltage supply which supplies voltage to the remote instruments is connected to the alarm annunciator to warn of abnormal fluctuations. If the voltage drops to 24 volts from the normal 27 volts, an alarm will sound and an abnormal light will appear on this station. The alarm can be silenced by acknowledging; however, the abnormal light at this station will continue to burn until the trouble is relieved.

APPENDIX D

References

Reactor Control Drawings

RC4-1-4	RC4-2-1	RC4-2-7	RC4-3-1
1-5	2-2	2-9	3-2
1-6B	2-3	2-10	3-3
1-7	2-4	2-11	6-2
1-8	2-5	2-12	
1-9	2-6	2-13	

Operating History from October 12, 1955, to Date

LITR log books
LITR daily report data sheets

APPENDIX E

STARTUP AND SHUTDOWN PROCEDURES FOR THE LITR

Reference

List of scrams and alarms, control desk procedure, and reactor control wiring diagram.

Purpose

Most of the hazards associated with reactor operations are likely to be encountered during startups and therefore the utmost attention should be paid to this part of operation. Shutdowns also are important, since they are useful for testing the safety systems; therefore over a period of a few weeks the entire safety system is tested in a regular cycle.

Responsibility

It is the responsibility of the supervisor and the control desk operator to see that all precautions and procedures are observed so that the hazards of reactor operations are minimized. It is the responsibility of reactor operations supervisors to authorize startups and to supervise all startups.

Procedure

Startup

A startup check list (attached) should be filled out before every startup. After the startup checks have been completed, the reactors should be started up according to the attached procedure. A supervisor must be present in the control room and is responsible for the startup. In the event of a scram, the reactor should be left down until the supervisor can come to the control room to supervise the startup.

Shutdown

The supervisor should prepare a shutdown sheet or schedule, listing in detail all the work to be done, for all scheduled shutdowns. For a weekly shutdown the schedule may be fairly elaborate, but for a shutdown for some special reason the schedule is much more simple. In general, the number of shutdowns should be kept to a minimum consistent with the experiments. Copies of startup and shutdown check lists and of the startup procedure and a sample of a typical weekly shutdown schedule are attached. The form for the weekly shutdown is filled out by the reactor supervisor the day prior to the shutdown.

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STARTUP CHECK LIST - LITR

(Revised 3-3-55)

	Date			
1. All work in core completed	_____	_____	_____	_____
2. Upper assembly of grids in place and seated properly	_____	_____	_____	_____
3. Top plug installed				
(a) Regulating rod connected	_____	_____	_____	_____
(b) All nuts in place around top plug	_____	_____	_____	_____
(c) All core experimental tubes in place and water seals made	_____	_____	_____	_____
(d) Lucite manhole cover in place and bolted down	_____	_____	_____	_____
(e) All electric wiring free of entanglements or potential entanglements	_____	_____	_____	_____
(f) All electrical connections made	_____	_____	_____	_____
4. Water flow started				
(a) Ample water supply in system	_____	_____	_____	_____
(b) Exit and inlet valves open; syphon break valve closed.	_____	_____	_____	_____
(c) Pump throttled with valve on high pressure side	_____	_____	_____	_____

(d) Pump started	_____	_____	_____	_____
(e) Throttling valve opened	_____	_____	_____	_____
(f) Reactor tank bled of air	_____	_____	_____	_____
(g) Top plug checked for leaks	_____	_____	_____	_____
(h) Water system operating properly	_____	_____	_____	_____
5. All beam hole work completed	_____	_____	_____	_____
6. Safety plugs in place, all required experiments tied into the reactor safety circuits and checked.	_____	_____	_____	_____
7. Gas flow through all ionization chambers and supply on hand	_____	_____	_____	_____
8. All recorders turned on	_____	_____	_____	_____
9. Fission chamber inserted far enough to read 2 counts/sec on counting rate meter	_____	_____	_____	_____
10. Regulating rod withdrawn	_____	_____	_____	_____
11. Servo turned on, amplidyne on, and demand at N_L	_____	_____	_____	_____
12. Reactor-on lights operating properly.	_____	_____	_____	_____
13. Log N calibrated and set for operation; period scram obtained	_____	_____	_____	_____
14. Magnet currents set to drop rods between 1.35 and 1.45 N_F	_____	_____	_____	_____

15. Lower limit switches checked and adjusted if necessary, with shim rod selector switch in "Off" position	_____	_____	_____	_____
16. Safety circuits checked with sigma buss scrams by raising and dropping rods	_____	_____	_____	_____
17. All lights on auxiliary annunciator panel normal	_____	_____	_____	_____
18. All components operating properly and reactor ready for startup	_____	_____	_____	_____
19. All research personnel alerted.	_____	_____	_____	_____
20. Startup completed; reactor and related equipment operating properly	_____	_____	_____	_____

STARTUP PROCEDURE FOR LITR

I. Checks To Be Made Before Reactor Startup

Experimental Holes

1. See that all experimental holes are plugged or otherwise ready for startup and that keys from all holes are in relay panel switch box.

2. Read log book for information on any in-pile experiments which might affect reactivity.

Instrumentation and Control Rods

1. Obtain control power and check to see that timer is working.

2. Turn shim rod switches to "normal". Magnets will go down to contact the shim rods.

3. See that the following recorders are turned on and operating as indicated; check log book for any changes:

   (a) both No. 1 and No. 2 safety recorders set at approximately zero;

   (b) period recorder set at approximately infinity;

   (c) log N may or may not be zero, depending on the length of the shutdown; be sure that this instrument is calibrated and set for operation;

   (d) fission chamber inserted far enough to register above 2 counts/second on counting rate meter; check count for accuracy by moving chamber and checking for changes in counting rate;

   (e) water temperature recorders on and indicating reasonable values.

4. Check for gas flow through all chambers.

5. Insure proper setting of magnet currents and drop points.

6. Check sigma buss amplifier resets to see that all lights are normal (upper row lighted). Test safety circuits with sigma buss scrams and reset.

7. Turn raise clutch switch to "raise". Turn on servo by turning servo-manual switch to "rod 1" position. This will cause the regulating rod to be fully withdrawn. Then turn the raise clutch switch to "off". Check to see that the servo demand indicator is at N_L; if it is not, have the servo checked. Set vernier at mid-scale.

Safeties

1. Turn scram switch to "normal" and check all "reactor-on" lights to see that they are burning.

2. Raise all three shim rods 1 inch and drop them by use of the scram switch. Do this three times if shutdown is to be of long duration (longer than 2 hours). Any trouble must be remedied before startup.

3. Locate all personnel. Be certain that no one is in the pit or other dangerous regions.

Complete LITR startup check sheet

II. Startup When Log N Is Below 0.001 N_L

1. See that all checks in Section I have been satisfactorily completed.

2. Record in log book any information relative to startup (e.g., purpose, special precautions, zero positions of recorders, etc.).

3. Start shim rods out

   (a) Turn shim rod switches to "preferred" or "normal".

   (b) Turn shim rod speed switch to "intermittent". Allow rods to withdraw until a definite period has been established and the log N meter begins to rise. The period meter will not allow the "intermittent" withdrawal to operate if the period exceeds 30 seconds. Normally, No. 2 shim rod is blocked at a position "$\sim$15", which permits No. 1 and No. 3 shim rods to be withdrawn completely, before full power is reached.

   (c) Use the "up-down" switch to complete the startup with No. 2 shim rod.

   (d) Maintain the period between 60 and 15 seconds by withdrawing or inserting No. 2 shim rod as required.

   (e) After the log N meter passes 0.1 and before it reaches 1.0, press the "start run" button.

(f) Keep the count rate meter fission chamber adjusted so that the meter does not go off scale.

(g) When the log N meter reaches N_L the servo should automatically take over. However, be prepared to insert the selected rod if the servo fails to accept control.

(h) When the servo takes over, insert or withdraw No. 2 shim rod until the regulating rod position indicator is at mid-scale (position 10.8 inches).

(i) See that the servo demand level vernier adjustment is at mid-scale. By use of the rough adjustment, increase the demand level on the servo by turning to "fast raise", while watching the pile period recorder to be sure that the period does not exceed 7 seconds. When the power is near the desired level, use the "slow raise" position until the power is very close. Use the vernier control knob to make final adjustment. Maintain the regulating rod at the half-way mark by adjusting No. 2 shim rod as the run progresses.

III. Startup When Log N Is Above 0.001 N_L

1. See that all checks in Section I have been satisfactorily completed.

2. Record in log book any information relative to startup.

3. Start shim rods out

(a) Turn shim rod positions to "preferred" or "normal".

(b) Turn shim rod speed switch to "high". It will have to be held in this position, since it is a spring-return position. Withdraw shim rods until a period of 30 to 15 seconds has been established. At a 30-second period the "high" speed switch becomes inactive and must be reset to be used again should the period fall below 30 seconds. If the period should reach 7 seconds, the power to withdraw rods is blocked out. If it reaches 5 seconds, the three rods will be automatically reversed to reduce the period.

(c) Normally, shim rods No. 1 and No. 3 are completely withdrawn after blocking No. 2 shim rod movement at some position (approx. 15 inches), usually before the N_L point on log N recorder is passed. Afterwards No. 2 shim rod is selected by push button, and variations in power are compensated by its use with the "up-down" switch, never exceeding a period of 10 seconds.

(d) Proceed as from Step (f) of Section II.

IV. Steady Operation

During steady operation checks are made at regular intervals, and data sheets are completed by the operator.

A. Reactor power

1. Check closely immediately after startup. Adjust the servo demand if required and maintain the regulating rod at mid-scale by adjusting No. 2 shim rod. Drift of power will decrease as system reaches equilibrium and will require somewhat less attention. The control console must not be left unmanned at any time during operation.

B. Ionization chamber gas flow

1. See that the gas flows on the chambers are maintained. There should be 0.5 cfm through each chamber.

2. Keep one full gas cylinder on each manifold in addition to the ones being used. Always order new cylinders when empties are removed from manifold.

3. Maintain the reactor water flow at 1200 gpm.

4. Check the pH of the water system every shift. It should be kept between 5.5 and 6.5. If it should be out of these limits, either high or low, add demineralized H_2O to bring the pH back within its limits. pH of make-up should be known.

C. Instruments

1. Check the correlation of the various instruments as to indication of the reactor power. Instrument adjustments should be made as frequently as necessary to keep them in good agreement.

2. Check the instrument charts frequently; they have a tendency to roll crookedly.

3. Check the magnet amplifiers frequently to see that the currents are normal and that no troubles are developing.

4. At least once an hour record all instrument readings.

V. Shutdowns

1. For normal shutdowns always use the scram switch, since this turns off the "reactor-on" lights. Instrument test shutdowns should be arranged periodically, however, to assure that the safety circuits are effective. When such shutdowns are performed, the scram switch should be thrown to "scram" immediately after the shim rods have dropped.

LITR SHUTDOWN CHECK LIST

Date _____

1. Scram switch in "Scram" position _____
2. Amplidyne off _____
3. Magnets raised _____
4. Pumps off _____
5. Control power off _____
6. Heat exchanger fans off _____
7. Demineralizer inlet valve closed _____
8. Pump discharge valve closed _____
9. Reactor discharge valve closed _____
10. Research checks made _____
11. Electrical connections removed _____
12. Regulating rod disconnected _____
13. Shim rod control switches in "off" position _____
14. Cooling water to heat exchanger off _____

LITR SCHEDULED WEEKLY SHUTDOWN

Date 6-5-56

Time 3:00 AM

A. Operations

1. Clean top plug and top level.

2. Check evacuation alarm.

3. Shut reactor down by reversing the shim rods to within 6 inches and then scramming by "raise clutch" switch .

4. Complete "LITR Shutdown Check List".

5. Prepare top plug for removal and remove to storage.

6. Perform isotope work (see item No. 15 for removal of top plug)

Isotope Stringer No.	Core Position
1	C-29
2	C-49
3	C-39
4	C-53

(a) Inventory isotope stringers.

7. Clean and inspect magnets.

8. Inventory and inspect core.

9. Inventory storage racks.

10. Check filters in the large filter housing.

11. Check pressure drop on LITR demineralizer lines and change filter if necessary.

12. Use south pump.

13. Complete startup check sheet.

14. Check the pressure drop across the filter in the off-gas system located at the midriff.

15. Remove the C-48 header box and attach the special waterproof plug to the tube.

16. Remove two CaO samples from C-21 and store them in N-7 storage can.

17. Degrease and scrub the top plug while it is in dry dock.

18. Continue transferring the old beryllium pieces from the storage racks to the Swimming Pool.

19. Check the C-28 tube before starting the pump.

20. Make the weekly and monthly mechanical and instrument checks.

21. Seat switches will be checked again and plans made for installation of new ones, if possible.

22. After completion of the startup check list, bring the reactor up to 1500 kw per instructions for experiment in HB-6. Operation will be at half power for one week.

RESEARCH

1. C-48: Experiment and vertical tube will be removed from the reactor and a new set installed.

2. C-44: Check to see whether vertical tube is ready for insertion.

3. C-46: The miniature dynamic corrosion loop will be removed from storage position W-6 and transferred to the large carrier for removal from the reactor. A crew will be on hand for this operation.

MAINTENANCE

1. Conduit will be installed between the large C-48 junction box and the safety circuit tie-in box above it. After the conduit is in, a cable will be rerouted through the conduit.

APPENDIX F

LITR CONTROL SWITCHES AND EFFECTS OF MISOPERATION

Listed below are all the operating switches in the LITR control room and the effect that manipulation of them will have upon reactor operation.

1. Scram switch: Will shut down the reactor.

2. Reverse bypass switch: The reverse switch will insert all shim rods and lower the reactor power. The bypass switch will have no effect.

3. Up-down switch: If operating in automatic control, the up switch will withdraw a selected shim rod, the amount being limited by a switch actuated by insertion of the regulating rod, which opens the withdraw circuit. If operating in manual, the up switch will withdraw a selected shim rod and increase the power level, the rate of increase being limited by the interlocks on the pile period recorder. The down switch will insert a selected rod and lower the power whether operating in servo or automatic.

4. Multiple switch: If the operating level is 1% of full power or above and if the "start-run" button has been pressed, will have no effect upon reactor operation. At levels below 1% of full power with reactor in "start" phase, will withdraw all shim rods, the limiting factor being the 30-second interlock on the period recorder.

5. Servo-demand switch: If actuated clockwise with the reactor in automatic control above 1% full power, will increase the power level by withdrawing the regulating rod; and if turned counter-clockwise will lower the power to 1% of full power by inserting the regulating rod and the shim rods.

6. Raise-clutch switch: Will shut down the reactor if thrown from "off" to "raise".

7. Count rate meter: Will have no effect upon reactor operation at constant power.

8. Servo-manual: If moved from rod 1 to manual, automatic control will be replaced with manual operation. If moved from manual to rod 1 with the regulating rod withdrawn at least 14 inches, will put the reactor into automatic control.

9. Shim rod position selector: If moved from "normal" or "preferred" on all rods, will make it impossible for the operator to withdraw a shim rod.

10. Fans "on" and "off" switch: If actuated, the temperature of the cooling water will fluctuate.

11. Water pump switch: If the "off" button is actuated, will stop the pump and shut down the reactor.

12. Reactor water pressure switch: If operated while the pressure line is being purged, will cause the reactor to be scrammed by the pressure recorder.

13. Electrometer on reactor water: If thrown to "off" position, will actuate the alarm annunciator but will have no effect on reactor operations.

14. Block out panel (a) exit and by-pass valve block, (b) water flow block: Neither one will affect the operation of reactor at constant power, although, if thrown, will actuate the alarm annunciator.

15. Emergency scram switches, located in the east and west experimental rooms and clearly identified: If actuated, either one will shut down the reactor.

APPENDIX G

INSTRUMENTS NOT REMOTELY MONITORED AND EFFECTS OF INSTRUMENT FAILURE

Part of the LITR instrumentation is not monitored at the remote site. These instruments and the effects of their failure upon the operation of the reactor are as follows:

1. Magnet currents: Will scram the reactor.

2. Thermohm recorder, which indicates temperatures of reactor water in A-tank, of reactor water inlet, and of reactor water exit: Will not affect the operation of the reactor.

3. Temperature recorder of reactor water beneath individual fuel elements: Will have no effect upon operation.

4. Ionization chamber voltage for fission chamber and galvanometer: Will have no effect upon operation at constant power.

5. Reactor water activity electrometer: This instrument is connected to the alarm annunciator to alarm if the activity level exceeds a predetermined setting; however, since the instrument can be cut off, no alarm will be given and there will be no effect on operation of the reactor.

6. Resistivity of reactor water: Will close a solenoid valve, thereby shutting down the LITR demineralizer but will have no effect on operation of the reactor.

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